SCIENCE EDUCATION IN AMERICA AT THE JUNIOR-HIGH-SCHOOL LEVEL DURING THE EIGHTEENTH AND NINETEENTH CENTURIES

BY

HEBER ELIOT RUMBLE

A.B., Oakland City College, 1924
A.M., University of Illinois, 1933

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN
EDUCATION IN THE GRADUATE SCHOOL OF
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FORMULATION OF THE PROBLEM

Statement of the problem. This is a summary of a study of *Science Education in America at the Junior-High-School Level during the Eighteenth and Nineteenth Centuries.* It was the purpose of this study to determine for the period 1776-1893, at the junior-high-school level, in the United States: (1) The *nature of the practices* in science education; (2) The *criticisms* made of, and the *proposals* made for science education; and (3) The *trends* and *tendencies* in the nature of, criticisms of, and proposals for science education.

Definitions of terms used. The *junior-high-school level* refers to that level corresponding to seventh, eighth, and ninth grades of present-day schools; to the first year of a four-year high school and the two years of formal schooling preceding entrance into the four-year high school. When necessary to determine junior-high-school level by considering chronological ages of students at that level, it was assumed that unretarded children would fall between the age limits of eleven to fifteen during the first months of a school year and twelve to sixteen during the last months of a school year. *Science* refers to the physical, biological, and earth sciences. *Science education* is that education by means of which the individual acquires experiences and understandings, as well as attitudes and a way of solving problems, through the study of scientific principles that will function in rendering more efficient his future behavior. Three phases of *science-education practices* were considered: (1) Subjects and subject matter and their organization; (2) Objectives of science instruction; and (3) Techniques of classroom procedure.

The sources used. The present account is based on verifiable sources which have been scrutinously examined. Nothing has been "read into" the records. The primary source material is composed of six kinds: (1) Publications, usually newspapers, magazines and yearbooks, in which educators have expressed their viewpoints on the educational issues of the day; (2) Federal, state, county and city reports, school laws, and reports of the work of private schools;

(3)Textbooks and supplementary materials designed for use by the pupil; (4) Special textbooks and manuals on methods for teachers; (5) Programs of studies, courses of studies, and school catalogues; and (6) Published personal letters, diaries and autobiographies.

The procedure used. The procedure used in this study was essentially that of historical research. The sources which were listed above were read with the aim of locating data applicable to the junior-high-school level. The data collected were of three types: (1) statements of practices in science education; (2) statements of criticisms of existing practices in science education and statements of proposals for new programs of science education; and (3) statements concerning trends and tendencies in science education practices, or of practices enabling one to determine trends and tendencies. A faithful attempt was made to identify all statements of practices, criticisms and proposals, and trends and tendencies, as to authorship, date of utterance or publication, dependability, and compass of auditors or readers. The data having been collected, according to a well-formed plan, they were organized to correspond to the nature of the thesis.

The limitations of this study. Some limitations of this study and the writer's treatment of the problem are inherent in the method used: (1) The prejudices of writers of any generation sometimes color their intended statements of fact; (2) In some cases there was a lack of clearness, and always possibilities of inaccuracies, as to science offerings in the schools; (3) The subjective element necessarily entered at times when the investigator was deciding whether certain data were applicable on the junior-high-school level; (4) The investigator depended almost wholly, except for personal books and a number of Inter-Library Loans, upon the data to be found in the University of Illinois Library; and (5) It was necessary to limit consideration of the nature of the science offerings to certain sections of the United States during the earlier years included in the study.

SUMMARY OF FINDINGS AND GENERALIZATIONS

The beginnings of science education. No records were found of science education being offered at the junior-high-school level in town or common schools of the colonial period. However, youth of junior-high-school age did receive some instruction in science: (1) through listening to the talks of ministers, public speakers, or

other prominent men interested in scientific topics; (2) through apprenticeship education, and working with parents in trades, or on farms and plantations; (3) through reading Latin books containing science materials recommended, or assigned, for outside reading by the Latin-Grammar-School master; and (4) through attendance at private schools.

By the period 1776-1827, widespread interest was manifest in certain fields of science. Men like Eaton, Silliman, Hare, Olmstead and others were helping to popularize science through textbooks and lectures and by founding scientific societies for the cultivation of the natural sciences. Many of the books of the period written for youth contained material, often in conversational form, concerning the seasons, barometers, fire, water, and so on. These writings, specifically designed as instructional materials for youth, emphasized first-hand study of things and phenomena. Among the didactic writers were Charlotte Sanders, Mrs. Mary Hughs, and Maria Edgeworth.

The nature of subjects and subject matter offered in different types of schools. As early as the last two decades of the eighteenth century, geography was offered at the junior-high-school level in American town and district schools. By 1827 geography was taught in most of the common schools, grammar schools, high schools, academies and seminaries and other types of quasi-private schools, offering work at the junior-high-school level. It was offered in the Boston Latin Grammar School. It was required by state laws to be taught in the common schools of Massachusetts and Vermont. It was encouraged by a New York State academy appropriation law which required students to have a knowledge of geography, such as was usually obtained in the common schools, before being considered as pursuing branches of an English education. During the last part of the period, 1776-1827, special science subjects were introduced, at the junior-high-school level, into high schools, academies, seminaries, and other private schools. Some of the sciences taught were astronomy, natural history, geology, mineralogy, botany, and even chemistry. By means of geography textbooks and school readers, the elements of these sciences were introduced into the common schools.

Geography textbooks written for the junior-high-school level during this period were encyclopaedic in nature and were meant to be memorized, and descriptive, rather than explanatory. The

method of beginning with the whole and analyzing through to the smaller units was employed by all authors until near the end of the period. Jedidiah Morse was the outstanding author of school textbooks in geography at this time. The science content found in geography textbooks of the period included chiefly material on astronomy, physical geography, subterraneous geography, and biological topics. Water, air, soil, movements of celestial bodies and eclipses, winds, clouds, etc., were common topics treated. Electricity, magnetism, heat, light, harvest moon, and similar topics were explained. Topics from many different sciences were introduced into the early geography textbooks.

Several school textbooks published for the use of pupils at the junior-high-school level dealt with various fields of science. Natural philosophy textbooks appear to have gained the greatest favor with those who planned school offerings. These textbooks contained material which today would be placed in physics textbooks, with the addition of many astronomical topics. Textbooks on astronomy became available near the end of the period. Chemistry textbooks were also being written, or copied and revised from English editions. Two of the most popular textbooks were revised editions of Mrs. Marcet's *Conversations on Natural Philosophy* and *Conversations on Chemistry*, first published in England. Botany textbooks, also, were published during the latter part of the period, chiefly intended for "young ladies." No physiology or anatomy textbooks appeared, although the subject was discussed in other books containing science material.

Early in the first decades of the nineteenth century school readers were published that contained much science material. Topics from agriculture, botany, astronomy, chemistry, natural philosophy, natural history, zoology, physical geography, and other sciences were introduced into the schools by way of reading lessons. Experiments were described and attempts were made to develop scientific attitudes. Many of the textbooks published during the period were intended to serve people of considerable difference in age and school level. There could be found in geography textbooks, special science textbooks, and the school readers, elements of science which are still considered suitable in terms of present-day junior-high-school science programs. Some material was found which would be omitted today. For example, beer and wine were sometimes called for in performing experiments. Some of the material included was not adapted to the student at the

junior-high-school level, but the teacher was expected to make the adaptation. The tendency near the end of the period to describe, to provide illustrations, to include experiments, and to discard the conversational and question and answer treatment, was very noticeable.

Throughout the subsequent period, 1827-1857, Lyceums were organized which attempted to develop an interest in collecting local science specimens for exchange between school children of different counties and states. Many lectures on science subjects were being given, and editors of periodicals were publishing articles and materials on science, some of which were recommended for use by the schools. Geography was taught in almost all schools and several additional states required geography taught in their common schools. Natural philosophy, astronomy, botany, chemistry, physiology, geology, and a few other sciences were being introduced into the common schools at the junior-high-school level, the extent of their adoption being in about the order here mentioned. As early as the fourth decade, records exist showing schools being used to further temperance instruction.

Relatively few high schools existed during the period, but many of those that did exist were offering geography, astronomy and natural philosophy, in varying combinations and amounts, to first-year students. At this level sometimes botany, natural history, natural theology, hygiene, anatomy, physiology, mineralogy, geology, and zoology were offered. By the end of the period, physiology, natural philosophy, and either political or physical geography were the common first-year high school subjects. The quasi-private schools welcomed youths of junior-high-school age who could pay the tuition fees. A common entrance age, particularly for female seminaries, was twelve years, and a complete program usually was planned to cover three years' work. A popular policy of the quasi-private institution was to teach what parents and pupils wanted taught, and usually at the level wanted. Geography, natural philosophy, astronomy, chemistry, and botany were the sciences usually taught at the junior-high-school level in the academies of this period.

During the next period, 1857-1876, geography was well established as a subject in the higher grades of the district and grammar schools, and many more states required that it be taught. In many of these schools, the elements of physiology, anatomy, hygiene, natural philosophy, physical geography, meteorology, geol-

ogy, chemistry, botany, zoology, and some of the other sciences also were being taught. During this period, the high schools customarily offered a science subject, usually physiology or physical geography, or sometimes two or three science subjects, in the first year. Physiology and physical geography often were offered for one term each, and then taught together for a third term. Botany in some schools was offered as an elective, or as a substitute course for physiology or physical geography. In others as a third science, or as the only science offered. Botany and zoology appear to have been considered as electives, while most other sciences, when offered, were required. Geography and natural philosophy were sometimes offered in the first year, but rarely geology, astronomy or chemistry. With few exceptions, the academies of the period continued to prescribe no course of study, the student being permitted to pursue the courses he thought best.

In 1861, Chicago adopted a graded course of instruction, written by Superintendent William H. Wells, for the elementary schools, and in it provided for an oral lesson of fifteen minutes each day on designated material, most of which, for the two higher grades, consisted of science subject matter. In the next to the highest grade, the students studied the properties of matter, laws of motion, physiology and hygiene; and in the highest grade, the students pursued lessons in popular astronomy and geology. Both classes had a regular course in geography. With some slight shifting of topics from one grade to another, these oral lessons were taught for several decades. The first year of the Chicago High School and the "High School Class" of a similar level located in the elementary schools, offered science, usually physiology and physical geography, although at various times natural philosophy, zoology (or natural history), botany and geography were offered.

In 1871, the St. Louis public schools, through the efforts of Superintendent William T. Harris, formulated a general plan for a science curriculum. It was a cycle, or spiral, plan where the topics were repeated in such a way that any pupil remaining in the St. Louis system for three years, with passing work, would know something of each of the great departments of science (nature). The subject matter provided for the seventh year was taken from the fields of geology, meteorology, botany, and zoology, and for the eighth year from the fields of meteorology and natural philosophy. For the time being physical geography continued to

be taught in the first year of the St. Louis High School, a one-year subject studied each school day. The grammar-school lessons were confined to one lesson each week on Wednesday afternoons, but sufficient time was to be given to each lesson to "allow a deep and lasting impression to be made."

By the period, 1876-1893, geography had obtained general recognition as an essential subject, many schools offering it every day in both seventh and eighth grades. Due to the active campaign of the Woman's Christian Temperance Union, during the ninth decade many states passed laws requiring elementary physiology and hygiene, "giving special prominence to the effects of alcoholic drinks, stimulants, and narcotics, upon the human system," to be taught in the public schools. In most cases the laws were complied with, for teachers were required to pass examinations in this field of science before receiving their teaching certificates. Teachers were introducing the elements of botany, natural history, natural philosophy, astronomy, geology, meteorology, mineralogy, astronomy, and even chemistry, into their schools, some forced by state laws, some influenced by courses of studies prepared by superiors as recommended material, and still others on their own initiative. The greatest diversity existed, however, with respect to the adoption of science subject matter as a part of the curriculum.

Early in the period, Celia Doerner, a Cincinnati district-school teacher, published an outline of science lessons which she and other teachers had used in the Cincinnati schools. In New York City, grammar-school teachers went to the Museum of Natural History in Central Park for instruction in natural history, and took back to their classrooms the information gained so as to teach natural history in an intelligent manner. Students often accompanied teachers to the Museum on field trips. In Massachusetts generally, elementary lessons on plants, animals, chemistry, physics, physical geography, etc., were being given in most of the public schools. Local exhibitions of the pupils' collections, drawings, and compositions were held and excited warm interest among parents. Milwaukee and other schools were offering courses in physical geography to eighth-grade students. Near the end of the period, students in the grammar schools of Pittsburgh were studying the local industries in manufacturing, commerce, and mining, in connection with their science course.

According to the system used in most schools, the plant was studied during the term devoted to botany, the bee waited

until the study of zoology, the pebble was treated in the lesson on geology, and so on. No attempt was made to study the environment as a whole. Parker, Straight, and Jackman at the Cook County Normal School, during the last years of the period 1876-1893, trained teachers to carry science instruction into the primary and grammar schools, and a science course was planned for that level. Science was believed to be one of the subjects of thoughtful study, along with geography and history; the unity of these subjects was to be found in the study of life. The natural sciences were to be the core of the curriculum. Jackman believed that life and its phenomena were dependent upon the physics and chemistry of air, land, and water, and manifested in animals and plants. It was to be studied under the heads of zoology, physics, meteorology, botany, geology, chemistry, astronomy, mineralogy, and geology. Jackman's outline was organized in terms of seasons and months of the year. He believed that observation furnished a mental picture which served as a basis for reasoning and interpretation. Not only observation, but experimentation and field work were important aspects of science education. Science was not to be *finished* in a month or a year, or in a lifetime.

In the high schools of the period 1876-1893, physiology was the preferred subject for the first-year science offering, usually given as a half-year or a whole-year course. Physical geography and botany, in that order, were next preferred. Physical geography was usually given for one-half year, while botany was usually a short-term subject, or possibly an elective. Zoology, natural philosophy, and geography were sometimes offered in the first year, and in isolated cases some of the other sciences. The academy was in the process of making way for the public high school. Freedom of choice still reigned in most of these schools.

Textbooks in political geography, during the period, 1827-1893, continued to present much science subject matter. The amount of astronomical material found in the political geography textbooks decreased throughout the period until by the end of the period it was more rare than common. Early in the first decades of the period, the authors introduced the discussion of the relation of plant and animal life to the environment. By the fifth decade, physical geography material was being emphasized in some of the political geography textbooks. Authors disagreed as to whether the physical geography subject matter should be treated as a separate unit or in connection with political geography material.

The latter viewpoint was favored during the last decades of the period, and although a section usually appeared treating physical geography material, it was also customary to introduce each grand division of the earth with physical geography material on that grand division. Several geographies published during this period arranged the material so as to begin the study at home. Gradually locational geography lost in relative emphasis to physical geography. The physical geography textbooks (which treated natural phenomena only) were introduced in 1855. The early writers organized the subject matter into three parts treating the three "spheres"—atmosphere, hydrosphere, and lithosphere—with sometimes an added part on plants and animals, or perhaps on the physical geography of the United States.

Some differences of opinion existed among writers as to what subject matter should be included in the early natural philosophy and chemistry textbooks. Astronomy was considered to be a part of natural philosophy early in the period but was soon recognized as a separate subject. Both the early natural philosophy and chemistry textbooks treated the various forms of energy, called the "imponderable agents." The authors of one series of science textbooks placed all their subject matter on electricity in their chemistry textbook. This material, however, finally found its place in the natural philosophy textbooks. During the third quarter of the nineteenth century, attempts were being made to make practical applications to everyday life. The scope of the material in the natural philosophy textbooks was still wide. Chemistry textbooks were now beginning to confine their material to the field of organic and inorganic chemistry, with some chemistry of the minerals. The chemistry and natural philosophy textbooks published during the last decade of the period show conclusively that the era of supremacy of the "Science of Common Things" had passed and that the new era of formal instruction had taken its place.

The early astronomy textbooks contained subject matter on the earth, the solar system, and the sidereal system. Later textbooks added material on practical astronomy. During the first part of the period, 1827-1893, the material referred to charts and celestial globes for observation work, but by the middle of the fourth decade, with the appearance of Burritt's *Geography of the Heavens*, the first-hand study of the stars, planets and constellations was being called for. Textbooks of the later years of the period were being written for levels higher than the junior-high-school level. No

geology textbook suitable for children of junior-high-school age was published during the first half of the period, although Hitchcock's geology was used. In 1886, Dana published a less difficult and more interesting work, but geology was gradually finding its place as a subject at higher levels, although much of its subject matter was introduced by way of oral lessons in the grammar grades.

The first botany textbooks published during the period, 1827-1893, were designed to aid students in recognizing and classifying plants. It was customary to begin the textbook with a scientific arrangement of plants, and add a section at the end of the textbook on the natural orders. New textbooks appeared, still emphasizing classification, but first giving a description of the several parts of plants. In 1857, Gray published his first textbook, and in 1858, a second, retaining the idea of classification, placing emphasis upon the structure, organs, growth, and reproduction of plants. He discussed the important uses of plants in the scheme of creation. Gray's influence was strong throughout the remainder of this period.

During the early decades of the period, 1827-1893, natural history and zoology were usually syonoymous terms so far as science textbooks were concerned. The subject matter found in natural philosophy textbooks was limited to a treatment of animals, their respiration, motions, instincts, senses, etc. By the seventh decade of the nineteenth century, much material on the characteristics and structure of animals, and on the branches of the animal kingdom, found a place in the natural history textbooks. Animals were classified, and then treated by classes. Steele's zoology appeared in 1872, and it divided the animals into invertebrates and vertebrates, and then into branches, and classes, before treating them in more detail. In this first book Steele began with the vertebrates and ended with the invertebrates. In 1887, the plan was reversed and the lowest invertebrates were treated first, and man, the highest vertebrate, was treated last.

In the early years of the period, the human physiology textbooks described the functions of the principal organs of the body. By the fourth decade of the nineteenth century, subject matter concerned with anatomy and hygiene, as well as physiology, appeared in the textbooks. The different organs of the system were first described according to structure, then as to function, and finally the conditions on which health and disease depend were

described. The method of treatment was wholly descriptive. By the eighth decade, the subject matter remained about the same, except that there was less separation of anatomy, physiology, and hygiene, and more blending of the three. By the ninth decade it was customary to find in physiology textbooks, subject matter concerned with the effects of alcoholic drinks and narcotics on the human body.

During the sixth decade of the nineteenth century, several books were published, consisting of questions and answers, treating the common phenomena of life, and drawing material from all science fields. Some of these books contained sections of experiments to be performed. One of these books was called *General Science*; another was *Peterson's Familiar Science.*

The nature of the objectives of science education. Attempts were made, in the period, 1776-1827, to utilize science as a means of training the faculties and reflective thinking. The dominant purpose of science material introduced into the schools, however, was the imparting of factual knowledge. It was thought that the educated person should know something about a great many things. The religious objective, with some writers, was strong. An acquaintance with nature, with astronomy and the biological sciences in particular, was expected to elevate and enlarge the pupil's views of "the wisdom and greatness of the Creator." There were many other minor objectives.

The informational and religious objectives continued to be emphasized throughout the period, 1827-1857. During this period the mental disciplinary objective received considerable attention, calling for the formation of the habits of attention and accurate observation, the development of good thinking, and the awakening of curiosity. By the beginning of the period, 1857-1876, insofar as actual practices were concerned, there was merely a shift in the relative emphasis upon the objectives. The dominant purpose of science instruction was still the imparting of factual knowledge, with the religious objective continuing to persist. More attention was being given to non-theological explanations of natural phenomena. Some emphasis was being placed on the utilization of the classified knowledge of science as a means of training the faculties. By the end of the period, mental discipline had become the controlling objective. Whatever else was claimed for a science, it was only infrequently that mental discipline of some sort was not men-

tioned. Training in observation, reflective thinking, understanding, the ability to draw inferences, all were considered important. The religious objective and the knowledge objective were still prominent but losing out to that of mental discipline, the religious much faster than the informational objective. By the middle of the eighth decade of the nineteenth century religion was almost a forgotten objective of science instruction, and to a less degree, so was the information objective. Mental discipline was still the ruling objective, with several additional objectives often thrown in on occasions to satisfy everyone. Training in observation, and the making of generalizations were commonly claimed objectives. By the end of the period, 1876-1893, the objective of science instruction in a few of the better schools was to develop a generalized mental ability; to develop power, judgment and ability to think. Some hoped to help children put common sense into their actions.

The nature of the techniques of classroom procedure. Late eighteenth-century science instruction was probably largely limited to having pupils read material from geography textbooks aloud to the teacher, or committing the geography textbook material to memory and then reciting it. Reciting of lessons committed to memory continued to be popular on into the nineteenth century. Much of the science material introduced into the schools came by way of reading lessons from geographies and readers. As the period approached its end, many teachers began to ask questions of the pupil and require an answer—an answer usually memorized from the textbook. Frequent reviews were a prominent part of instruction. Some teachers required themes to be written which often contained science material. Earlier in the period, almost all students had been taught as individuals; later the monitorial plan introduced group instruction.

There were teachers, usually in private schools, who lectured familiarly to their students during the late eighteenth and early nineteenth centuries. A few of the instructors of the early nineteenth century had available considerable apparatus to use in science instruction. The teachers in the common schools were not so fortunate in this respect; but some of the teachers in the private schools often were well supplied with equipment. One of the best equipped schools was the Boston Monitorial School. Many teachers improved their own equipment or asked for donations from parents and friends of the school. Where apparatus was available, experi-

mentation usually was carried on. One teacher used the crayon and blackboard, natural objects, and science apparatus in his teaching. Some of the teachers—William Fowle and William Smith are two good examples—taught very much as do many science teachers of today, by lecture and demonstration. No doubt, however, that the majority of the science materials taught during the period was by some other method than that of experimental demonstration.

Prominent educators teaching at the junior-high-school level were introducing new methods during the third decade of the nineteenth century. Sequence of subjects was receiving attention, there being a gradual passage from more easy to more difficult material. The inductive system, embracing ideas of Pestalozzi combined with the systematic arrangement of Lancaster, was being tried. Teachers were trying to develop in youth the ability to communicate ideas properly to others. There were attempts to improve upon the question and answer method in common use.

During the early part of the period 1827-1857, textbook teaching, with memorization, was still in use, but the inductive method of instruction was gaining in favor. In the academies and high schools, the illustrated lectures by means of science apparatus, models, mineral collections, animal and plant specimens, engraved drawings, and demonstration experiments were very popular. The illustrated lecture method soon found its way into the grammar grades on a less extensive scale. By about the middle of the fifth decade, oral instruction and the use of the blackboard came into favor. Much diagraming was used as a medium of "visible illustration" in teaching the parts of plants and animals, and even scientific principles. Also used for illustration were globes, orreries, telluriums, tide-dials, and mineral, animal and plant collections. Outside professional men were welcomed into the schools to give lectures on scientific subjects. Students rarely were permitted to perform experiments in natural philosophy or chemistry, but they could examine the mineral, plant and animal collections, bring in specimens of their own, and make first-hand examination of the movements of the heavenly bodies. Field trips were made by some teachers and pupils to observe permanent collections, or to collect specimens of their own.

Oral teaching was the method that dominated the period 1857-1876. It was a Pestalozzian form of instruction which called for careful observation, reasoning, and self-expression. Illustrations were to be introduced as often as practicable. The child was being

encouraged to investigate for himself, form his own opinions, and express them in his own words. It was to be a process of self-development. Emphasis was placed on the descriptive side. Near the end of the period some teachers had the pupils keep lecture books in which they recorded experiments demonstrated; others introduced individual laboratory instruction where the pupil performed experiments. The blackboard continued to be used. The topical method of recitation was generally admitted as being superior, but the use of the method was less general than the belief in the method. Many teachers were satisfied to teach without apparatus and specimens, even though these were readily available.

During the period, 1876-1893, instruction at the grammar-school level continued to be by *"oral instruction,"* with much emphasis being placed on *"visible illustrations"* and the *"inductive method."* The use of science apparatus, charts, models, and specimens to illustrate that which was being taught was customary in the better schools. In some of the schools at the grammar-school level, students performed experiments in natural philosophy and chemistry; they procured hearts, lungs, bones, muscular tissue, etc., from the butcher for study; and they collected minerals, animals and plants for observation. In some of the schools at this level the students, with the help of the teacher, made simple science equipment. At the proper seasons, collections of living buds, sprouting seeds, and zoological, botanical, and mineral specimens could be found in many classrooms. In the majority of the high schools at the first-year level, more textbook work was done, with a few experiments being performed by the teacher. In other high schools the individual laboratory method was being introduced. Between these extremes all conceivable variations were to be found.

Criticisms and proposals concerning early science education practices. During the period, 1776-1827, teachers were often declared incompetent to teach science. It was said that the programs of studies were not varied enough; science was not emphasized as it should be. Females, in particular, were not offered the educational opportunities they deserved; they were not offered certain materials in science which were being made available to males. In the early years of the period it was claimed that science books were written by the English for the English, and were not suitable for American school children. In later years, as American authors began to write, the textbooks were criticized because they were

organized for memorization, and for deductive instruction instead of for inductive teaching. The methods of instruction centered around memorization rather than around training in reflective thinking. It was claimed, truthfully, that textbooks in many of the special sciences, which were understandable by students of junior-high-school age, were not available. Few teachers, it was maintained, had sufficient science apparatus available to instruct students in many of the principles of science.

It was proposed that some plan for developing better teachers should be devised. Science should be taught to teachers and potential teachers in training institutions. The programs of studies for the students at the junior-high-school level should be widened so as to include more science. In two years the elements of instruction might be acquired; the remaining eight years should be used for instruction in science and other higher branches of knowledge. Females should be instructed on a higher level than the common and grammar schools were offering. Textbooks, particularly geographies, should be written so as to begin with home material. Textbooks in the special sciences, suitable for children at the junior-high-school level, should be written for introduction into the schools. Students who were to learn science must work or perform operations on it. Increased use of apparatus in science teaching was proposed. Students should be taught familiarly, thoroughly; taught to *examine*, *inquire*, and *to think*. Demand of them not only *what* but *why* and *wherefore*. It was proposed that education should not consist only in the acquisition of knowledge but in the development of the mind. Teach *ideas* rather than words.

Criticisms and proposals concerning subjects and subject matter offered. During the period, 1827-1857, many persons were still criticizing the meagerness of the science offerings at the junior-high-school level but others were objecting to the fact that science instruction was being introduced. There was disagreement as to whether a child should be taught science subject matter before he was able to fully comprehend it. Such men as Samuel Hall, Horace Mann, Bronson Alcott, Henry Guyot and Asa Gray favored science education in the schools. By the period, 1857-1876, it was claimed by some that to teach the sciences was not the business of the common schools because: (1) teachers were not prepared for it; (2) the minds of the pupils were still too feeble to master the sciences; (3) the tendency was to produce *smatterers*; and (4) that teachers

were neglecting the fundamental subjects, and the teaching of those who left school early, for the "ologies and osophies."

The prominence into which the branches of physical science had thrust themselves by the wonderful discoveries, and, if possible, still more wonderful applications of them, was causing the workers to become loud in their demand for the "bread and butter" sciences. Horace Greeley, America's most famous journalist of the period, and moulder of public opinion, lead the cry for the introduction of those sciences into the schools which were the bases of a sound practical knowledge of things. And schoolmen, such as John D. Philbrick, James Pyle Wickersham, William T. Harris, and others were calling for a revision of the common school curriculum. By the end of the period, 1857-1876, they were suggesting that there was an immense waste of time in teaching the studies usually taught in the common schools, and that if the subject matter of these subjects were properly selected and the time properly utilized, enough time might be gained for the introduction of science material. The educational world was in a ferment of discussion.

In 1859, Thomas Hill had proposed that the child at the junior-high-school age begin studying the elements of science in the fields of astronomy, natural philosophy, geography, botany, zoology, anatomy and physiology; then he would add the elements of optics, acoustics, thermotics, and gradually give more attention to chemical changes; finally, the pupil would study the elements of chemistry, electricity and magnetism. From England came the suggestion of Herbert Spencer that there was to be instruction in science for all. Michael Faraday had testified that he could teach a boy of eleven to understand all those things in mechanics, hydrostatics, hydraulics and optics, which were usually taught much later. In America, Dana, in geology, and Agassiz, in natural history, were speaking for science instruction, and were being listened to with respect. In 1876, the National Education Association Committee on the "Course of Study from Primary School to University," with Harris as its chairman, recommended that children should study some phase of science at all levels. In the schools below the high school, geography would be studied, and there would be oral lessons in natural philosophy and natural history. Several sciences were recommended for high school study but the grade level for each science was not given.

By the beginning of the period, 1876-1893, the idea was being expressed widely that the course of study for each grade level should best prepare the student to step *out* of school rather than for stepping *up* to the next grade, for so many students dropped out of school early and they too, should be properly trained for life. It was said to be conceivable that the two preparations might coincide. The question with educators appeared to be whether the program was overcrowded because of the introduction of new subjects, or because of the additions made to the old; and just what were the essential subjects. Charles McMurry, Col. Francis Parker, Charles W. Eliot, Wilbur Jackman and others advocated the introduction of science into the schools, science that made for better homes, health, fertility of the soil, etc., and in every lesson, *function* was to lead the way. Several addresses by Eliot led to the appointment of the Committee of Ten to study the secondary school program. The Committee reported with its nine "Conferences," three on science, in 1893, and instead of confining its recommendations to the secondary level, made recommendations for grades below the high school.

The Conference on Physics, Chemistry and Astronomy urged that the study of simple phenomena be introduced at the grammar-school level at least one period each day. The Conference on Natural History asked that not less than two periods a week in the grammar grades be given to natural history, but that physiology not be studied at the junior-high-school level. The Conference on Geography recommended that the study of physical geography—a broad treatment of the physical features of the earth, atmosphere, and ocean, and of the forms of life and their physical relations—be pursued in the later grammar grades. When the Committee of Ten finally presented their recommended programs of studies for various types of high schools, the study of physical geography was chosen as the science field to be offered in the first year of high school.

Criticisms and proposals concerning objectives of instruction. Throughout the period, 1827-1893, the objectives proposed for science education were somewhat similar to the objectives commonly used in practice, except that the former appeared earlier in point of time. During the last years of the period some educators were claiming that those who emphasized the disciplinary value of science had missed the primary problem of education. It was

not a question of how strong was the mind, but what was its quality and temper. The study of nature was to give the child an intelligent and rational understanding of his natural environment and of the applications of natural science to human industry and comfort. Science was to root out superstition. It was to bring the pupil to a strong personal realization that he was the focus of innumerable forces which were bearing upon him from without, and so limited his life and comfort, as to render an absolute necessity to him the knowledge of how they may be resisted, guided, and controlled. Mental discipline was not necessarily of primary importance, but natural science was to make possible a strong development of will-energy because its interesting materials furnished strong and legitimate incentives to mental activity. Such men as Wilbur Jackman and Charles McMurry were proposing these new objectives of science education. The three Conferences working with the Committee of Ten and treating the science fields, also proposed objectives for science instruction at the junior-high-school level along with other levels. An interpretation of their reports brings out the following objectives of science instruction at the junior-high-school level: (1) to develop an interest in nature; (2) to develop the powers of observation, scientific imagination, and reasoning; (3) to develop the habit of investigating carefully and making clear truthful statements; and (4) to acquire, by actual experience, classified knowledge.

Criticisms and proposals concerning techniques of classroom procedure. It is true, also, that throughout the period, 1827-1893, the techniques of classroom procedure proposed for science education had been somewhat similar to the techniques adopted in practice except, as in the case of the objectives, the proposals came before the commonly accepted practices. Late in the period, there arose two schools of thought regarding the laboratory method of instruction. Some believed that a full course of didactic instruction should precede the admission of students into the laboratory; others held that laboratory and classroom work should go side by side from the beginning. Experiments were to be performed not only to illustrate facts and principles but to give familiarity with the use of common instruments. Teaching was to be inductive rather than dogmatic. It was being proposed that science instruction be correlated with other subjects of the program. Laboratories, even in the grammar schools, were being called for. Science teaching indoors was to be reinforced by nature outside. It was proposed

that material be arranged in a succession of topics or unities each of which might be treated separately, and then in relation to the others. The steps to be used in teaching a lesson were: (1) Preparation; (2) Presentation; (3) Association and comparison; (4) Generalization; and (5) Practical Application.

The Committee of Ten recommended that all students were to be instructed alike, whether they intended to go to the university or drop out of school early in life. The physical sciences were to be pursued chiefly, though not exclusively, by means of experiments in the use of simple instruments for making measurements. Things and phenomena were to be studied direct. Meteorology, in the grammar school, was to be taught as an observational study, the scholars being made familiar with the use of the thermometer, the wind-vane, and the rain-gauge. Science subjects, particularly natural history and geography, were to be correlated with drawing, history, literature and language.

Trends and tendencies. Certain trends are evident. During the period, 1776-1827, the trend was to teach more science, particularly geography, natural philosophy, astronomy, chemistry, and botany; to discipline the mind as well as to fill it full of facts and to offer rational proof of a Creator. The proponents advocating science education at the junior-high-school level were increasing in number; the practices were moving in the direction of the proposed goals.

Throughout the period, 1827-1893, the trend continued to be to teach more science material. Geography, physical geography, and physiology were gaining in favor as subjects to be offered at the junior-high-school level. The practice of offering the elements of natural philosophy, physiology, botany, meteorology, geology and zoology as oral lessons to students at the grammar-school level was gaining in favor. There was a trend near the end of the period to move physical geography from the ninth grade to the eighth grade, and to introduce more of the biological science material into the first year of high school; the Committee of Ten, however, in their report, proposed that physical geography be the ninth-grade science subject.

As for objectives, the trend throughout the period, 1827-1893, was for the mental disciplinary objective to supplant the informational and religious objectives. Near the end of the period, due to the proposals coming from the layman, there was a trend to place emphasis on the practical aim.

As for techniques of classroom procedure, the trend throughout the period, 1827-1893, was away from memorization work and toward oral lessons, inductive teaching, the topical method, and the study of nature first-hand. There was a trend to use more "visible illustration"; the blackboard, science equipment, models and other means of supplementing direct study of natural phenomena were coming into favor. Near the end of the period there was a trend to introduce the individual laboratory method of instruction.

Throughout the period, 1776-1893, many writers of science textbooks, school administrators, editors of magazines and newspapers, and science educators were very influential in popularizing science education for pupils of the junior-high-school area, and in determining the nature of practices in subject matter taught, objectives of instruction, and techniques of classroom procedure. Some individuals during every decade have stood out above all others, and exerted as significant influence in their day as Liberty Hyde Bailey, Gerald S. Craig, Otis W. Caldwell, Ira C. Davis, Wilbur A. Beauchamp or Francis D. Curtis have done since that period.

Among those who should be mentioned are men and women like Jedidiah Morse, William Fowle, Maria Edgeworth, Mrs. Jane Marcet, J. L. Comstock, James Carter, Samuel Hall, Horace Mann, A. Bronson Alcott, Mrs. Lincoln Phelps, Montgomery Bartlett, Catherine Beecher, George Emerson, Richard Green Parker, R. E. Peterson, Asa Gray, Arnold Guyot, W. P. Atkinson, Rev. Thomas Hill, Horace Greeley, James Dwight Dana, James Pyle Wickersham, John D. Philbrick, William H. Wells, J. Dorman Steele, Mrs. Mary H. Hunt, William T. Harris, Charles W. Eliot, Col. Francis W. Parker, Henry H. Straight, Wilbur Jackman and Charles McMurry.

Very few new ideas regarding subject matter taught, objectives of instruction, or techniques of classroom procedure, were introduced into the schools during the nineteenth century. It was merely a matter of relative emphasis. Almost all practices proposed or used during the period had been proposed or used by some teachers during the late eighteenth and early nineteenth centuries.

The trend throughout the period, 1776-1893, was for practices to follow in the path of strongly supported proposals, but the tendency on the part of most teachers was to continue to use practices fixed by tradition long after their appropriateness was open to question.

VITA

Heber Eliot Rumble was born September 4, 1903, son of Mr. and Mrs. Chester A. Rumble, in Glezen, Indiana. He was graduated from the Stewartsville High School, Stewartsville, Indiana, in May, 1921. He attended Oakland City College, Oakland City, Indiana, from 1921 to 1924, and received the A.B. degree from this institution in June, 1924. He studied at the University of Wisconsin during the summer session of 1926. He was enrolled at the University of Illinois during the summer sessions of 1927, 1928, 1929, 1931, and 1932, studying in the fields of science, history, and education; he enrolled in the Graduate School in 1929. He was enrolled in the Graduate School of the University of Illinois during the academic year of 1932-1933, and received the A.M. degree in Education in June, 1933. From 1933 to 1943 he has done additional work in science, and additional graduate work in the Department of History and the Department of Education, University of Illinois. He is a member of Kappa Delta Pi and Phi Delta Kappa.

He was employed as a science and history teacher and athletic coach at the Fairmount High School, Fairmount, Illinois, during the year 1924-1925, and served in a similar capacity at Oxford Township High School, Alpha, Illinois, during the period 1925-1928. He was employed as a science teacher and athletic coach at the Champaign High School, Champaign, Illinois, during the period 1928-1935. Since 1935 he has been the Chairman of the Science Department and Director of Visual Aids at the Champaign Junior High School, Champaign, Illinois.

He has written the following articles:

"Science Education at the Junior-High-School Level, *Circa* 1776-1827," *School Science and Mathematics*, 42: 724-728, November, 1942.

"Morse's School Geographies: An Eighteenth-Century Science Textbook Series Used at the Junior-High-School Level," *Journal of Geography*, 42: 174-180, May, 1943.

"A Junior High School Buys a Jeep," *School Activities*, 14: 342-344, May, 1943.